greater average occupancy of spectrum from a coordinated system could increase the interference potential to other services, undermining the Commission's intent to establish spread spectrum standards to facilitate spectrum sharing. In the *Notice*, the Commission proposed to permit the operation of frequency hopping spread spectrum systems that individually and independently choose and adapt their hopsets to react to the environment in which the system is operating, moving themselves out of the way should another user come on the air in the same band.[108]

49. Adtran, Apple, Digital Wireless, Part 15 Coalition, and Rockwell supported the proposal in the *Notice*.[109] Apple believes that the coordination provision should be permitted in the 915 MHz, 2450 MHz and 5800 MHz bands. Adtran and Digital Wireless state that the Commission should address the situation of collocated transmitters to prevent virtual synchronization and may wish to limit the number of collocated adaptive systems. Digital Wireless requests that adaptive hopsets be permitted, where the number of hops may drop below the minimum number in order to avoid collisions with another system. Master Lock states that if a system is designed to drop a channel from the hopset because it is in use, then the rules should require that dropped channel be reassessed within 20 seconds and either be reinstated or replaced by another channel in order to maintain the minimum number of required channels.[110]

50. Tadiran Telecommunications, Inc. (Tadiran) states that coordinated transmitters should be permitted provided the transmitters are isolated from one another by means of physical separation or antenna directivity, or if the number of coordinated transmitters is small.[111] Lucent opposes Tadiran's request to permit coordination among collocated transmitters and asks that the Commission clarify that centralized coordination of systems is not allowed.[112] Lucent supports the Commission's coordination proposal but asks for clarification that the coordination is between a single transmitter-receiver pair engaged in communication. Further, Lucent believes it is unnecessary to limit the number of collocated transmitters provided each transmitter independently adapts its hopping sequence. Metricom asks that the Commission clarify that the prohibition against the coordination of frequency hopping systems applies only to intrasystem coordination and does not restrict a transmitter's ability to avoid occupied channels.[113]

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the entire 915 MHz band would be occupied on a continuous basis, allowing no room for other users.

[108] *See Notice* at para. 43.

[109] *See* Adtran Comments at 6; Apple Comments at 5; Digital Wireless Comments at 1; Part 15 Coalition Comments at 6; Rockwell Comments at 8.

[110] *See* Master Lock Reply Comments at 4.

[111] *See* Tadiran Comments at 1, 4-8.

[112] *See* Lucent Reply Comments at 3.

[113] *See* Metricom Reply Comments at 6.

51. The proposal in the *Notice* that would permit coordination between intelligent frequency hopping transmitters would not result in an increase in interference potential to other users of the spectrum. Such systems are able to detect interfering sources, both from other spread spectrum transmitters and from other radio services, and avoid operating on occupied portions of the spectrum. By avoiding operation on frequencies used by other radio services, the principle Part 15 operational requirement that the equipment not cause harmful interference to other users of the spectrum is fulfilled. However, permitting frequency hopping systems to directly coordinate their hopping sequences, as requested by Tadiran, would not necessarily enable these systems to avoid operation on portions of the spectrum used by any other radio operators. The suggestion by Tadiran to require coordinated transmitters to be isolated from one another by distance or antenna directivity would not ensure that interference is not caused to other radio services, but would serve only to reduce the interference that the co-located spread spectrum system causes to itself. Further, absent station licensing, the Commission can not readily control the number of Part 15 spread spectrum transmitters in any given location nor can it ensure that coordinated transmitters are properly isolated from other users of the spectrum. Thus, permitting a frequency hopping system to coordinate its hop sequences in a direct fashion could result in the system monopolizing the spectrum and could cause interference to other operators trying to use the same spectrum. Accordingly, the Commission is amending its regulations to permit the operation of frequency hopping systems that incorporate intelligence that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopping sequence to avoid hopping on occupied channels. It is not permitting the coordination of frequency hopping systems using other methods for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple systems. Manufacturers are reminded that such systems must continue to comply with the other standards applicable to spread spectrum systems, including the minimum number of hopping channels and the channel maximum dwell times.

8. External radio frequency power amplifiers.

52. As stated in the *Notice*, several companies appear to be marketing external radio frequency power amplifiers to increase the transmission range of Part 15 spread spectrum transmission systems.[114] It also appears that several manufacturers are marketing replacement antenna systems with higher directional gains to increase transmission range. The marketing and use of these amplifiers or antennas violates Federal law and the Commission's regulations.[115] The rules specifically limit the output power of the transmitter, the EIRP from the combination of the transmitter and the antenna, and the levels of the radiated emissions in certain restricted

[114] *See Notice* at para. 44.

[115] *See* 47 USC §§ 301 and 302. *See* also, 47 CFR § 15.1.

frequency bands.[116] The addition of an external radio frequency power amplifier or of an antenna other than the one with which the spread spectrum transmission system was originally certified can cause the system to exceed these limits and the use of this system to violate the rules. However, the Part 15 rules do not specifically discuss external amplifiers or replacement antennas as such. Thus, the Commission acknowledges that some equipment manufacturers may not be aware of these requirements. Accordingly, in the *Notice* the Commission proposed to clarify its regulations by adding a new section prohibiting the manufacture, importation, marketing and use of external radio frequency power amplifiers intended for use with Part 15 transmitters unless those amplifiers are certified as part of a Part 15 system. Similarly, the Commission proposed to amend the regulations to state that the use of an antenna, other than the type with which the product was originally certified, is in violation of the rules. Since the prohibition against the use of external amplifiers or after-market antennas is equally applicable to all Part 15 transmission systems, it further proposed that this amendment apply to all Part 15 transmission systems.

53. Several parties, including Adtran, Apple, Cushcraft, Cylink and the Part 15 Coalition, support the intent of this proposal. Adtran supports a prohibition of external amplifiers and higher gain antenna replacements but wants an exclusion for professional installation of equivalent antennas from different manufacturers.[117] Similarly, Digital Wireless requests an exclusion for high-gain antennas since these systems cannot practically be sold with attached antennas.[118] Adtran and Cushcraft request that the use of alternate antennas be allowed as either Class I or Class II permissive changes.[119] MDS and WMC specifically oppose the language proposed in the *Notice* for in the proposed Section 15.204(d). MDS is concerned because it produces a software controlled radio that would have to be approved with each antenna.[120] WMC requests that the proposed Section 15.204(d) be deleted so that high gain antennas may be used with professional installation.[121]

54. The Commission is adopting its proposal as detailed in the *Notice*. In accordance with 47 USC 302, radio frequency devices must comply with the Commission's standards as a condition of manufacture, marketing and use. These requirements include obtaining a grant of certification for the transmitter and meeting the emission limits specified in the rules. The Commission will not certify an external radio frequency power amplifier under Part 15 of its rules as a stand-alone device. However, it will certify such an amplifier as part of a system since

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[116] *See* 47 CFR §§ 15.205 and 15.247. The regulations also require that the transmitter be designed to prevent the use of any antenna other than the one with which it was originally certified. *See* 47 CFR § 15.203.

[117] *See* Adtran Comments at 7.

[118] *See* Digital Wireless Comments at 3.

[119] *See* Adtran Reply Comments at 2; Cushcraft Comments at 3-4.

[120] *See* MDS Comments at 3-4.

[121] *See* WMC Comments at 2.

it is the specific combination of transmitter, amplifier and antenna that determines whether or not the resulting system will comply with the standards. If an external amplifier has not been certified as part of the system but is employed with a Part 15 transmitter, the certification on the transmitter is no longer valid.[122]

55. With regard to the antenna employed with the system, changes to the antenna certified with the system often will change the amplitude levels of both the fundamental and the unwanted emissions. The Commission is particularly concerned about possible increases to emissions appearing in frequency bands allocated to sensitive radio services or services used for safety-of-life applications. Thus, changes to the antenna can be made only if the equipment continues to comply with the standards. Further, changes to the antenna may be made only by the holder of grant of certification following the procedures for Class II permissive changes specified in Part 2 of the regulations.[123] In order to simplify the measurement requirements when a manufacturer wishes to produce a transmitter that can be used with several different antennas, the Commission has permitted tests of representative antennas instead of requiring the transmitter to be tested with each possible antenna; however, this testing criteria is established on a case-by-case basis and is dependent on the specific type of transmitter and antennas being employed. Additional information on how to simplify the test requirements when multiple antenna choices are being made available should be obtained from the Commission's Laboratory staff just prior to the equipment being tested in preparation for submission for a grant of certification.

9. RF exposure hazards.

56. In the *Notice*,[124] the Commission noted that, absent controls regarding the locations and manner in which spread spectrum transmitters may be used, systems employing high gain directional antennas could expose the public to potentially harmful signal levels that exceed the radio frequency exposure limits set forth in the rules and recommended by various standards-setting organizations.[125] In order to meet its obligation under the National Environmental Policy Act, the Commission proposed to consider the holder of the grant of certification for the transmitter, the grantee, responsible for ensuring that the equipment is designed to minimize exposure of the public to excessive radio frequency (RF) signal levels.[126] Comments were requested on possible methods of incorporating a warning of some type into the equipment

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[122] *See* 47 CFR § 2.1043(a) and (b)(3)

[123] *See* 47 CFR § 2.1043(b) and especially § 2.1043(b)(3).

[124] *See Notice* at para. 14.

[125] The Commission recently adopted new RF guidelines for human exposure. *See Report and Order* in ET Docket No. 93-62, 11 FCC Rcd 15123 (1996); *Memorandum, Opinion and Order* in ET Docket No. 93-62, 11 FCC Rcd 17512 (1996). *See* also, 47 CFR § 1.1307(b)(1).

[126] *See* 42 USC § 4321 *et seq.*

design. Comments were also requested concerning possible biological hazards from the high effective radiated power levels that could be emitted from these systems, additional methods that can be employed to prevent unnecessary exposure of the public, and whether the Commission should prescribe the use of specific means for preventing such exposure.

57. The commenters agree that cautionary information regarding any potential RF hazard is sufficient, either as warning signs near the antenna or as information in a user/installation manual. They oppose the use of proximity sensors or any other preventive methods that would interrupt transmissions. Apple, Cylink, the Part 15 Coalition and Metricom support using the ANSI/IEEE standard for RF exposure to ensure protection from high gain antennas.[127] Additionally, the Part 15 Coalition recommends that the equipment certification grantee be responsible for ensuring compliance with the RF hazard standard. Finally, WMC requests that the proposed amendment to Section 15.247(b)(4)(v) be deleted or that the rule be applied to all RF emissions, whether the emissions come from Part 15 devices or from equipment operating under some other rule part.[128]

58. The Commission agrees with the comments that cautionary information regarding potential RF hazards, either as warning signs near the antenna or as information in a user/installation manual is a step that could be taken by the responsible party to ensure that the system is operated in accordance with the RF guidelines for human exposure adopted by the Commission. However, it is the responsibility of the installer and the user of the equipment to ensure that the public is not exposed to excessive RF levels. Further, these RF hazard requirements apply to all radio frequency devices, not just to Part 15 spread spectrum transmitters. The Commission is amending its rules to clarify this issue.

10. Cross border operation.

59. In the *Notice*,[129] the Commission noted that informal comments raising concerns with the WMC petition, particularly regarding operation in the 2450 MHz band, have already been received from the staff at Industry Canada, an agency of the Canadian Government. Similarly, the Mexican Government has expressed its concern regarding unlicensed spread spectrum operations between stations in the U.S. and stations in Mexico.[130] Because of this, comments were requested on actions that could be taken to limit operation near the Canadian and Mexican borders to avoid unauthorized crossborder operations and interference to licensed systems in

[127] *See* Apple Comments at 8; Cylink Comments at 10; Part 15 Coalition Comments at 5; Metricom Reply Comments at 9.

[128] *See* WMC Comments at 3.

[129] *See Notice* at para. 15.

[130] Unlicensed operation in the Part 15 spread spectrum bands is not permitted in Mexico.

Canada and Mexico.

60. Many commenters, including AT&T, Columbia Gas, the Part 15 Coalition, Rural Cellular, and WMC, opposed any restrictions that would limit transmissions or the use of high gain antennas near the Canadian or Mexican borders. These parties believe that existing rules contain adequate protection to prevent interference. The Part 15 Coalition states that it opposes any restriction on equipment use within the U.S. near the borders but would support a prohibition on cross-border transmissions.[131] WMC believes that directional antennas will help minimize any signals into Canada or Mexico because transmissions will be directed towards receivers within the United States.[132]

61. As previously indicated, the operation of Part 15 devices is subject to the condition that no harmful interference be caused to other radio operations. This requirement also applies to harmful interference caused to Canadian or Mexican radio operations. The Commission believes that this requirement, in combination with the standards applicable to these systems, is sufficient to protect radio systems operating in Canada or Mexico. Further, the Commission emphasizes that agreements between the U.S. and Canada or Mexico to permit cross-border operation do not exist. Accordingly, the Commission can not authorize cross-border operation.

11. Interference to LMS services.

62. Apple requests that Part 15 of the rules be amended to reflect the presumption of non-interference for Part 15 devices operating in the frequency bands allocated to wideband multilateration LMS services. This statement currently is contained in Section 90.361 of the rules, and addresses the operating conditions under which a Part 15 spread spectrum transmitter in the 915 MHz band is presumed not to cause interference to wideband multilateration LMS services.[133] The Commission does not agree that these provisions should be placed in Part 15 of its rules. These provisions were developed in conjunction with the LMS rule making and any changes to the regulations would be associated with that radio service. Further, and most important, placing these provisions in Part 90 of the rules serve to alert LMS operators that they can not claim harmful interference has occurred from most spread spectrum operations. There are no similar provisions that permit operators of Part 15 devices to ameliorate harmful interference from wideband multilateration LMS operations.

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[131] *See* Part 15 Coalition Comments at 5.

[132] *See* WMC Comments at 9.

[133] *See* 47 CFR § 90.361.

12. Reduction in the number of hopping channels at 2450 MHz and 5800 MHz.

63. In the *Notice*, the Commission denied the petition from Symbol Technologies, Inc. to reduce the number of hopping channels in the 2450 MHz and 5800 MHz bands.[134] Several of the comments indicated agreement with this decision.[135] However, GEC Plessey Semiconductors (GPS) requests that the Commission reconsider its decision to permit wider bandwidth channels to support wireless LAN systems. Tadiran also requests that the Commission reduce the minimum number of frequency hopping channels to permit wider bandwidths to be employed.[136] Neither of these parties offer new or novel arguments that were not previously considered by the Commission in its denial of the Symbol petition. Tadiran indicates that it would be desirable to avoid operating in the frequency range of 2450-2483.5 MHz due to the allocation to broadcasters and private microwave licensees. However, Tadiran fails to account for similar problems that would occur in the 2400-2450 MHz band due to operations in the Amateur Radio Service or to other radio frequency noise produced throughout the 2450 MHz band by ISM equipment. Accordingly, the Commission is reaffirming its previous decision denying a reduction of the minimum number of frequency hopping channels for spread spectrum systems operating in the 2450 MHz and 5800 MHz bands.

D. Transition provisions

64. The amendments being adopted in this proceeding clarify permissible methods of operation. With the exception of limits on directional antenna gain versus transmitter output power for systems in the 2450 MHz band, these amendments should not impact any existing equipment designs. As mentioned above, waivers were issued previously to WMC, Cylink Corporation, Atlantic Communications Sciences, MDS, Larus Corporation and Wi-LAN to manufacture fixed, point-to-point spread spectrum systems in the 2450 MHz and 5800 MHz bands without a limit on directional antenna gain. These manufacturers would be impacted by a decision to reduce the output power of a 2450 MHz transmitter by 1 dB for every 3 dB the directional antenna gain exceeds 6 dBi. Under the terms of the waivers, this equipment can only be manufactured until final action in this proceeding.

65. Cylink requests that any restrictive regulations to limit antenna gain in the 2450 MHz band be phased in over a twelve month period to permit the completion of any existing

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[134] *See Notice* at para. 18-25 and 49.

[135] *See*, for example, Adtran Comments at 4; Digital Wireless Corporation Comments at 2; Fusion Lighting Comments at 2; International Microwave Power Institute Comments at 1; Lucent Technologies Comments at 2; Rockwell Comments at 5; TIA Wireless Comments at 4.

[136] Tadiran, in late filed comments, also requests that a linear reduction in power be applied with the decrease in the number of hopping channels.

contractual obligations.[137] However, Cylink, along with the other manufacturers that were issued waivers, was aware of the possibility that its waiver may not continue subsequent to finalization of this rule making proceeding. Any contractual obligations based on a temporary, and possibly non-continuing, waiver must be considered to have been taken at the manufacturer's own risk. Accordingly, the Commission sees no reason to delay the effective date of these amendments to the regulations. While the Commission originally proposed to make these amendments effective upon the date of publication of the final rules in the Federal Register,[138] the Contract With America Advancement Act of 1996[139] requires that these amendments not become effective prior to 30 days from publication in the Federal Register.

IV. PROCEDURAL MATTERS

Final Regulatory Flexibility Analysis

66. As required by Section 603 of the Regulatory Flexibility Act, 5 U.S.C. § 603 (RFA), Initial Regulatory Flexibility Analysis (IRFA) was incorporated in the *Notice of Proposed Rule Making* ("*Notice*") in ET Docket No. 96-8.[140] The Commission sought written public comments on the proposals in the *Notice* including the IRFA. The Commission's Regulatory Flexibility Analysis (FRFA) in this Report and Order conforms to the RFA, as amended by the Contract with America Advancement Act of 1996 (CWAAA), Public Law No. 104-121, 110 Stat. 847 (1996).[141]

1. Need for and Objective of the Rule.

67. The objective is to amend Parts 2 and 15 of the rules regarding the operation of spread spectrum transmission systems in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The Commission is also adopting a number of amendments to the spread spectrum regulations to clarify the existing regulations, to codify existing policies into the rules, and to update the current definitions. These changes to the rules will facilitate the growth of the spread spectrum industry by enabling and encouraging practical applications for these products. The new rules will expand the ability of equipment manufacturers to develop spread spectrum systems for unlicensed use that provide users with the flexibility to establish radio links without

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[137] *See* Cylink Comments at 15.

[138] *See Notice* at para. 45.

[139] Pub. L. No. 104-121, 110 Stat. 847 (1996).

[140] Amendment of Parts 2 and 15 of the Commission's Rules Regarding Spectrum Transmitters, 11 FCC Rcd 3068 (1996).

[141] Subtitle II of the CWAAA is "The Small Business Regulatory Enforcement Fairness Act of 1996" (SBREFA), codified at 5 U.S.C. § 601 et seq.

the delays and costs associated with formal frequency coordination and licensing. Such uses may include intelligent transportation system communications links; high speed Internet connections for schools, hospitals, and government offices; energy utility applications; PCS and cellular backbone connections; and T-1 common carrier links in rural areas. The new rules will also permit frequency hopping spread spectrum systems and wideband, multilateration Location Monitoring Service (LMS) systems to operate within the same frequency band with decreased potential for mutual interference problems.

2. Summary of Significant Issues Raised by the Public Comments in Response to the Initial Regulatory Flexibility Analysis.

68. Only one commenter, Adtran submitted comments that were specifically in response to the IRFA. It agrees with the Commission's assessment that the changes made in the R&O will have no negative impact on small entities. In general, commenters were supportive of the Commission's proposed changes to the rule. The Commission also received numerous suggestions for improving or modifying the rules. In response to a Petition for Rule Making filed by WMC, the Commission is eliminating the limit on directional gain antennas for spread spectrum transmitters operating in the 2450 MHz and 5800 MHz bands. For spread spectrum systems operating in the 2450 MHz band, the Commission is implementing its proposal to require that the output power for the transmitter be reduced by 1 dB for every 3 dB that the directional gain exceeds 6 dBi. In addition, in response to a Petition for Rule Making filed by SpectraLink, the Commission is reducing, from 50 to 25, the minimum number of channels required for frequency hopping spread spectrum systems operating in the 915 MHz band.

3. Description and Estimate of the Number of Small Entities Subject to Which the Rules Apply.

69. The RFA generally defines the term "small business" as having the same meaning as the term "small business concern" under the Small Business Act, 15 U.S.C. §632. Based on that statutory provision, we will consider a small business concern one which: (1) is independently owned and operated; (2) is not dominant in its field of operation; and (3) satisfies any additional criteria established by the Small Business Administration (SBA). The RFA SBREFA provisions also apply to nonprofit organizations and to governmental organizations. Since the Regulatory Flexibility Act amendments were not in effect until the record in this proceeding was closed, the Commission was unable to request information regarding the number of small businesses that manufacture spread spectrum transmitters and is unable at this time to determine the number of small businesses that would be affected by this action. However, the Commission believes that the amendments being adopted in this proceeding clarify permissible methods of operation. With the exception of limits on directional antenna gain versus transmitter output power for systems in the 2450 MHz band, these amendments should not impact any existing equipment designs. The only parties that would be impacted by the requirement to reduce transmitter output power when high antenna gains are employed are WMC, Cylink, ACS, MDS, Larus, and Wi-LAN Inc. These companies are currently producing this equipment under the conditions of a temporary waiver that permits them to manufacture fixed, point-to-point

spread spectrum systems in the 2450 MHz band without a limit on directional antenna gain. All of these companies were notified at the time the waivers were granted that the waivers would expire upon the date of final action in this proceeding.

70. The rules adopted in this R&O will apply to any entities manufacturing equipment for unlicensed Part 15 spread spectrum transmitters. The Commission has not developed a definition of small entities applicable to manufacturers of spread spectrum transmitters. Therefore, the applicable definition of small entity is the definition under the Small Business Administration ("SBA") rules applicable to manufacturers of "Radio and Television Broadcasting and Communications Equipment". According to the SBA's regulations, radio frequency manufacturers must have 750 or fewer employees in order to qualify as a small business.[142] Census Bureau data indicates that there are 858 companies in the United States that manufacture radio and television broadcasting and communications equipment, and that 778 of these firms have fewer than 750 employees and would be classified as small entities.[143]

4. Description of Projected Reporting, Recordkeeping and Other Compliance Requirements.

71. Part 15 spread spectrum transmitters are already required to be authorized under the Commission's certification procedure as a prerequisite to marketing and importation. The changes proposed in this proceeding would not change any of the current reporting or recordkeeping requirements. Further, the proposed regulations add permissible methods of operation and would not require the modification of any existing products, except for those currently operating under limited waivers that expire upon adoption of this R&O. These requirements include obtaining a grant of certification for the transmitter and meeting the emission limits specified in the rules.

72. Skills of an application examiner, radio technician or engineer will be needed to meet the requirements. In many cases the studies can be done by a radio technician or engineer. Certification applications are usually done by applications examiners. It is the responsibility of the manufacturer of the device to determine whether the device will comply with the RF radiation limits. This study can be done by calculation or measurement, depending upon the situation.

5. Significant Alternatives and Steps Taken by Agency to Minimize Significant Economic Impact on a Substantial Number of Small Entities Consistent with Stated Objectives.

73. In response to concerns raised in comments filed in response to the *Notice*, the Commission made several minor clarifying amendments to its proposals. However, there was only one issue raised in the comments that could have had a significant economic impact on the manufacturers of spread spectrum systems. In the *Notice*, the Commission proposed to require

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[142] *See* 13 C.F.R. § 121.201, Standard Industrial Classification (SIC) Code 3663.

[143] *See* U.S. Department of Commerce, *1992 Census of Transportation, Communications and Utilities* (issued May 1995), SIC category 3663.

that the 3 dB beamwidths of the high gain directional antennas employed with spread spectrum transmitters differ by no more than a factor of two between the vertical and horizontal planes.[144] Supporting comments were received from Adtran and Digital Wireless; however, Cushcraft, Cylink, the Part 15 Coalition and WMC believe that the requirement is an unnecessary regulation. Cushcraft believes that the majority of antennas already meet this criterion. Cylink states that this proposal may prevent applications that require a different antenna design, such as communications to off-shore platforms. The Commission agrees with the latter commenters that this portion of its proposal is unnecessary.

6. Commission's Outreach Efforts to Learn of and Respond to the Views of Small Entities pursuant to SBREFA 5 U.S.C. § 609.

74. During the course of this proceeding Office of Engineering and Technology staff members have had numerous ex parte meetings with representatives from Metricom, Inc., Cylink Corporation, Mulcay Consulting Association, and Digital Wireless Corporation.

7. Report to Congress.

75. The Commission shall send a copy of this Final Regulatory Flexibility Analysis, along with this Report and Order, in a report to Congress pursuant to the Small Business Regulatory Enforcement Fairness Act of 1996, 5 U.S.C. § 801(a)(1)(A). A copy of this FRFA will also be published in the Federal Register.

V. ORDERING CLAUSES

76. Accordingly, IT IS ORDERED that Parts 2 and 15 of the Commission's Rules and Regulations ARE AMENDED as specified in Appendix B, effective 30 days after publication in the Federal Register. This action is taken pursuant to Sections 4(i), 301, 302, 303(e), 303(f), 303(r), 304 and 307 of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154(i), 301, 302, 303(e), 303(f), 303(r), 304 and 307.

77. For further information regarding this Report and Order, contact the Office of Engineering and Technology, John Reed at (202) 418-2455 or Anthony Serafini at (202) 418-2456.

FEDERAL COMMUNICATIONS COMMISSION

William F. Caton
Acting Secretary

[144] *See Notice* at para. 17.

APPENDIX A

LIST OF COMMENTING PARTIES

Comments
Adtran
Alliant Techsystems, Inc.
American Petroleum Institute
Apple Computer, Inc.
AT&T Wireless Services
Columbia Gas Transmission
Cushcraft Corporation
Cylink Corporation
Digital Wireless Corporation
The Ericsson Corporation
Fusion Systems Corporation
Fusion Lighting, Inc.
Gabriel Electronics, Inc.
GEC Plessey Semiconductors
International Microwave Power Institute
Itron, Inc.
Lucent Technologies Inc.
Mario Proietti
Master Lock Company
Metricom, Inc.
Microwave Communications Technology Inc.
Microwave Data Systems
OCOM Corporation
Oneonta Telephone Company, Inc.
Part 15 Coalition
Questar InfoComm, Inc.
RadioShack Division of Tandy Corporation
RAMAR Technology, Ltd.
Rural Cellular Corporation
Scott Townley
Sola Communications, Inc.
SpectraLink Corporation
Tadiran Telecommunications, Inc.
Telecommunications Industry Association , Wireless Consumer Communications Section
Teletrac License, Inc.
United States Cellular Corporation
Western Multiplex Corporation

Late Filed Comments
Multipoint Networks, Inc.
Rockwell International Corporation
Tadiran Telecommunications, Inc.

Reply Comments
Adtran
CellNet Data Systems
Cylink Corp.
Digital Wireless Corporation
Itron, Inc.
Lucent Technologies Inc.
Master Lock Company
Metricom, Inc.
Mulcay Consulting Associates
Part 15 Coalition
SpectraLink Corporation
Telecommunications Industry Association, Fixed Point-to-Point Communications Section
Telecommunications Industry Association, Wireless Consumer Communications Section
Teletrac License, Inc.
US West, Inc. (US West)
Western Multiplex Corporation

APPENDIX B

CHANGES TO THE REGULATIONS

I. Title 47 of the Code of Federal Regulations, Part 2, is amended to read as follows:

1. The authority citation for Part 2 continues to read as follows:

AUTHORITY: Sec. 4, 302, 303, and 307 of the Communications Act of 1934, as amended, 47 U.S.C. Sections 154, 302, 303 and 307, unless otherwise noted.

2. Section 2.1, paragraph (c), is amended by deleting the definition for "pseudorandom sequence" and by revising the following definitions to read as follows:

Section 2.1 Terms and definitions.

* * * * *

(c) * * *

* * * * *

Direct Sequence Systems. A spread spectrum system in which the carrier has been modulated by a high speed spreading code and an information data stream. The high speed code sequence dominates the "modulating function" and is the direct cause of the wide spreading of the transmitted signal.

* * * * *

Frequency Hopping Systems. A spread spectrum system in which the carrier is modulated with the coded information in a conventional manner causing a conventional spreading of the RF energy about the frequency carrier. The frequency of the carrier is not fixed but changes at fixed intervals under the direction of a coded sequence. The wide RF bandwidth needed by such a system is not required by spreading of the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop. The test of a frequency hopping system is that the near term distribution of hops appears random, the long term distribution appears evenly distributed over the hop set, and sequential hops are randomly distributed in both direction and magnitude of change in the hop set.

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II. Title 47 of the Code of Federal Regulations, Part 15, is amended to read as follows:

1. The authority citation for Part 15 continues to read as follows:

AUTHORITY: Secs. 4, 302, 303, 304, 307 and 624A of the Communications Act of 1934, as amended, 47 U.S.C. 154, 302, 303, 304, 307 and 544A.

2. Section 15.3 is amended by adding a new paragraph (bb), to read as follows:

Section 15.3 Definitions.

* * * * *

(bb) External radio frequency power amplifier. A device which is not an integral part of an intentional radiator as manufactured and which, when used in conjunction with an intentional radiator as a signal source, is capable of amplifying that signal.

3. Part 15 is amended by adding a new Section 15.204, to read as follows:

Section 15.204 External radio frequency power amplifiers and antenna modifications.

(a) Except as otherwise described in paragraph (b) of this section, no person shall use, manufacture, sell or lease, offer for sale or lease (including advertising for sale or lease), or import, ship, or distribute for the purpose of selling or leasing, any external radio frequency power amplifier or amplifier kit intended for use with a Part 15 intentional radiator.

(b) A transmission system consisting of an intentional radiator, an external radio frequency power amplifier, and an antenna, may be authorized, marketed and used under this part. However, when a transmission system is authorized as a system, it must always be marketed as a complete system and must always be used in the configuration in which it was authorized. An external radio frequency power amplifier shall be marketed only in the system configuration with which the amplifier is authorized and shall not be marketed as a separate product.

(c) Only the antenna with which an intentional radiator is authorized may be used with the intentional radiator.

4. Section 15.247 is amended by revising paragraphs (a)(1)(i), (b), (c), (d), and (e), and by adding new paragraphs (g) and (h) before the note at the end of the section, to read as follows:

Section 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

(a) * * *

(1) * * *

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) * * *

(2) * * *

(b) The maximum peak output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz or 5725-5850 MHz band and for all direct sequence systems: 1 watt.

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) Except as shown below, if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the above stated values by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(4) Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. *See* § 1.1307(b)(1) of this Chapter.

(c) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

(d) For direct sequence systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

(e) The processing gain of a direct sequence system shall be at least 10 dB. The processing gain represents the improvement to the received signal-to-noise ratio, after filtering to the information bandwidth, from the spreading/despreading function. The processing gain may be determined using one of the following methods:

(1) As measured at the demodulated output of the receiver: the ratio in dB of the signal-to-noise ratio with the system spreading code turned off to the signal-to-noise ratio with the system spreading code turned on.

(2) As measured using the CW jamming margin method: a signal generator is stepped in 50 kHz increments across the passband of the system, recording at each point the generator level required to produce the recommended Bit Error Rate (BER). This level is the jammer level. The output power of the intentional radiator is measured at the same point. The jammer to signal ratio (J/S) is then calculated, discarding the worst 20% of the J/S data points. The lowest remaining J/S ratio is used to calculate the processing gain, as follows: $Gp = (S/N)o + Mj + Lsys$, where Gp = processing gain of the system, (S/N)o = signal to noise ratio required for the chosen BER, Mj = J/S ratio, and Lsys = system losses. Note that total losses in a system, including intentional radiator and receiver, should be assumed to be no more than 2 dB.

* * * * *

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

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APPENDIX C

FEDERAL COMMUNICATIONS COMMISSION

Equipment Authorization Division
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Guidance on Measurements for Direct Sequence Spread Spectrum Systems

Part 15 of the FCC Rules provides for operation of direct sequence spread spectrum transmitters. Examples of devices that operate under these rules include radio local area networks, cordless telephones, wireless cash registers, and wireless inventory tracking systems.

The Commission frequently receives requests for guidance as to how to perform measurements to demonstrate compliance with the technical standards for such systems. No formal measurement procedure has been established for determining compliance with the technical standards. Such tests are to be performed following the general guidance in Section 15.31 of the FCC Rules and using good engineering practice. The following provides information on the measurement techniques the Commission has accepted in the past for equipment authorization purposes. Alternative techniques may be acceptable upon consultation and approval by the Commission staff. The information is organized according to the pertinent FCC rule sections.

Section 15.31(m): This rule specifies the number of operating frequencies to be examined for tunable equipment.

Section 15.207: Power line conducted emissions. If the unit is AC powered, an AC power line conducted test is also required per this rule.

Section 15.247(a)(2): Bandwidth. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span >> RBW.

Section 15.247(b): Power output. This is an RF conducted test. Use a direct connection between the antenna port of the transmitter and the spectrum analyzer, through suitable attenuation. Set the RBW > 6 dB bandwidth of the emission or use a peak power meter.

Section 15.247(c): Spurious emissions. The following tests are required :

(1) RF antenna conducted test: Set RBW = 100 kHz, Video bandwidth (VBW) > RBW, scan up through 10th harmonic. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band *as measured with a 100 kHz RBW.*

(2) Radiated emission test: Applies to harmonics/spurs that fall in the restricted bands listed in Section 15.205. The maximum permitted average field strength is listed in Section 15.209. A pre-amp (and possibly a high-pass filter) is necessary for this measurement. For measurements above 1 GHz, set RBW = 1 MHz, VBW = 10 Hz, Sweep: Auto. If the emission is pulsed, modify the unit for continuous operation, use the settings shown above, then correct the reading by subtracting the peak-average correction factor, derived from the appropriate duty cycle calculation. See Section 15.35(b) and (c).

Section 15.247(d): Power spectral density. Locate and zoom in on emission peak(s) within the passband. Set RBW = 3 kHz, VBW > RBW, sweep = (SPAN/3 kHz) e.g., for a span of 1.5 MHz, the sweep should be $1.5 \times 10^6 \div 3 \times 10^3 = 500$ seconds. The peak level measured must be no greater than +8 dBm. If external attenuation is used, don't forget to add this value to the reading. Use the following guidelines for modifying the power spectral density measurement procedure when necessary.

- For devices with spectrum line spacing greater than 3 kHz no change is required.
- For devices with spectrum line spacing equal to or less than 3 kHz, the resolution bandwidth must be reduced below 3 kHz until the individual lines in the spectrum are resolved. The measurement data must then be normalized to 3 kHz by summing the power of all the individual spectral lines within a 3 kHz band (in linear power units) to determine compliance.
- If the spectrum line spacing cannot be resolved on the available spectrum analyzer, the noise density function on most modern conventional spectrum analyzers will directly measure the noise power density normalized to a 1 Hz noise power bandwidth. Add 34.8 dB for correction to 3 kHz.
- Should all the above fail or any controversy develop regarding accuracy of measurement, the Laboratory will use the HP 89440A Vector Signal Analyzer for final measurement unless a clear showing can be made for a further alternate.

Section 15.247(e): Processing Gain. The Processing Gain may be measured using the CW jamming margin method. Figure 1 shows the test configuration. The test consists of stepping a signal generator in 50 kHz increments across the passband of the system. At each point, the generator level required to produce the recommended Bit Error Rate (BER) is recorded. This level is the jammer level. The output power of the transmitting unit is measured at the same point. The Jammer to Signal (J/S) ratio is then calculated. Discard the worst 20% of the J/S data points. The lowest remaining J/S ratio is used when calculating the Processing Gain.

In a practical system, there are always implementation losses which degrade the performance below that of an optimal theoretical system of the same type. Losses occur due to non-optimal filtering, lack of equalization, LO phase noise, "corner cutting in digital processing", etc. Total losses in a system, including transmitter and receiver, should be assumed to be no more than 2 dB.

The signal to noise ratio for an ideal non-coherent receiver is calculated from:

(1) $Pe = \frac{1}{2}e^{(-\frac{1}{2}(S/N)o)}$

where : Pe = probability of error (BER)
$(S/N)o$ = the required signal to noise ratio at the receiver output for a given received signal quality

This is an example. You should use the equation (or curve) dictated by your demodulation scheme.

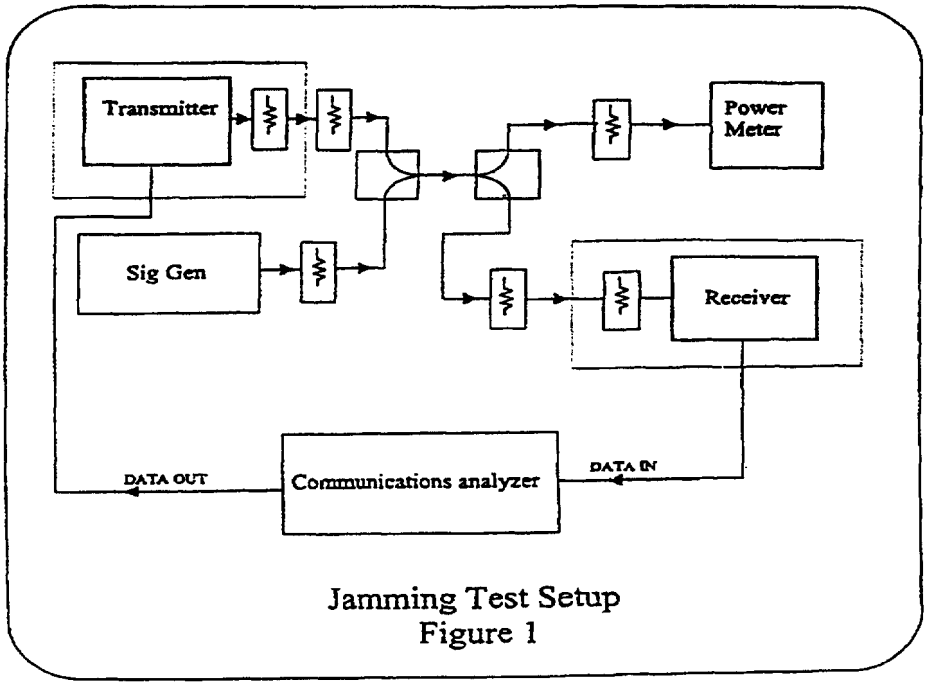
Ref.: Viterbi, A. J. Principles of Coherent Communications, (New York: McGraw-Hill 1966), Pg. 207

Using equation (1) shown above, calculate the signal to noise ratio required for your chosen BER. This value and the measured J/S ratio are used in the following equation to calculate the Processing Gain (Gp) of the system.

$Gp=(S/N)o+Mj+Lsys$

where: $(S/N)o$ = Signal to noise ratio
Mj = J/S ratio
$Lsys$ = System losses.

Ref.: Dixon, R., Spread Spectrum Systems (New York: Wiley, 1984), Chapter 1.



Jamming Test Setup
Figure 1

ALTERNATIVE TEST PROCEDURES

If antenna conducted tests cannot be performed on this device, radiated tests to show compliance with the various conducted requirements of Section 15.247 are acceptable. As stated previously, a pre-amp must be used in making the following measurements.

1) Calculate the transmitter's peak power using the following equation:

$$E=\frac{\sqrt{30PG}}{d}$$

Where: E is the measured maximum field strength in V/m utilizing the widest available RBW.
G is the numeric gain of the transmitting antenna over an isotropic radiator.
d is the distance in meters from which the field strength was measured.
P is the power in watts for which you are solving:

$$P=\frac{(Ed)^2}{30G}$$

2) Measure the power spectral density as follows:

A. Tune the analyzer to the highest point of the maximized fundamental emission. Reset the analyzer to a RBW = 3 kHz, VBW > RBW, span = 300 kHz, sweep = 100 sec.

B. From the peak level obtained in (A), derive the field strength, E, by applying the appropriate antenna factor, cable loss, pre-amp gain, etc. Using the equation listed in (1), calculate a power level for comparison to the +8 dBm limit.